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Short Communication

Chironomidae (Diptera) from mountain lakes of the Eastern Carpathians, Romania: First records and insight into diversity

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Abstract

Lakes at high altitudes are extremely sensitive to environmental stressors at both local and global scales, making them important sentinels of the changing world. Chironomidae, the most diverse group of benthic macroinvertebrates inhabiting mountain lakes, respond to various environmental impacts, making them important bioindicators of the lake's ecological status. This study aimed to provide the first insight into chironomid diversity in high-altitude lakes from two mountain ranges of the Romanian Eastern Carpathians: the Maramures, and the Rodna Mountains. Floating chironomid material was collected by skimming the water surface with a hand net from 16 lakes at elevations ranging from 1378 to 1922 m a.s.l. A total of 50 species/ taxa were collected, including nine new records for Romania. Notes on newly recorded species' distribution, ecology and taxonomy are provided. In addition, an identification key for *Procladius choreus* and *P. sagittalis* based on thoracic horn characteristics is given. With our addition, the total number of chironomid species known from Romania is now 526. The study provides a baseline for future research on chironomid diversity, ecology, and biogeography in high-altitude lakes of the Carpathian Mountains.

Key words: Biomonitoring, high-altitude lakes, males, Maramures Mountains, new record, non-biting midges, *Procladius* identification key, pupal exuviae, Rodna Mountains

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Introduction

Chironomidae is the most diverse group of benthic macroinvertebrates inhabiting high-altitude lakes and ponds, where they can represent twice the diversity of all other macroinvertebrate groups and often predominate quantitatively as well (e.g., Lods-Crozet et al. 2012 and references therein). Due to these attributes, chironomids are considered a good surrogate for benthic macroinvertebrates in ecological studies and biomonitoring programs (Ruse 2010).

The sensitivity of chironomid species to various environmental impacts, such as climate change, long-range air pollution, and species introduction, makes this insect group important bioindicators in both contemporary and palaeoecological studies (Nicacio and Juen 2015 and references therein).

Understanding the regional chironomid fauna of mountain lakes is the first step towards using the species for lake status assessment and further monitoring. Additionally, faunistic data from contemporary limnological studies can aid in the interpretation of paleolimnological data in mountain regions (Battarbee and Bennion 2012).

Our ongoing limnological research on chironomid fauna in alpine lakes of the Eastern Carpathians has shifted from the Chornohora and Svydovets Mountains in Ukraine (Bitušík et al. 2020, 2024) to the Maramures and Rodna Mountains in northern Romania.

In this study, we provide the first insight into the diversity of the Chironomidae family in mountain lakes of these ranges, including species recorded in Romania for the first time. The results will serve as baseline information for further research on chironomid diversity, ecology, and biogeography in Carpathian lakes, as well as a basis for long-term monitoring of lake ecological status and as a prerequisite for developing appropriate management and protection strategies for these ecosystems.

Material and methods

Study area and sampling sites

The study was carried out on 16 lakes within two orographic units of the Eastern Carpathians in northern Romania: the Maramures, and the Rodna Mountains (Fig. 1).

Both massifs are extensive, covering an area of 1500 km^2 with a length of around 100 km (Maramures Mts) and 1300 km^2 with a length of almost 50 km (Rodna Mts). The Rodna Mts are the highest range in the Romanian Eastern Carpathians, with peaks exceeding 2200 m, while the Maramures Mts reach a maximum elevation of 1957 m.

The geology of both massifs primarily consists of crystalline rocks (gneiss, epimetamorphic schists, mica schists) penetrated by eruptive rocks (dacites, andesites, rhyolites) and sedimentary rocks (conglomerates, sandstone, clay schist, shale, marl, clay; Curtean-Banaduc et al. 2008; Chis 2010).

Both mountain ranges have a moderate temperate continental climate with Atlantic and Baltic influences. Based on data from the Iezer meteorological station (Rodna Mts, 1785 m a.s.l.), the mean annual temperature is 1.4 °C, mean air summer temperature is 9.4 °C, mean July air temperature is 10.3 °C, and the annual precipitation is 1240 mm, applicable to lakes at or above the natural timberline (1700–1850 m) (Kucsicsa 2011). Adjusted to 1360 m a.s.l., the forest zone has an average annual temperature of 3.4 °C, a mean summer temperature of 11.6 °C, and a mean July air temperature of 12.5 °C (Farcas et al. 2013; Diaconu et al. 2017).

The Rodna Mts were heavily glaciated during the Last Glacial Maximum and show clear glacial imprints, such as glacial cirques, lakes, and peatbogs (Mindrescu and Evans 2014). There are about 23 lakes in the Rodna Mts, each with a surface area under 0.5 ha and a maximum depth of 5.2 m (Chis 2010). In contrast, Pleistocene glaciation had a lower impact on the Maramures Mts (Costea 2008). The lakes of glacial origin there are generally small, and many are in an advanced terrestrialization phase or have already turned into peat bogs (Chis 2010).

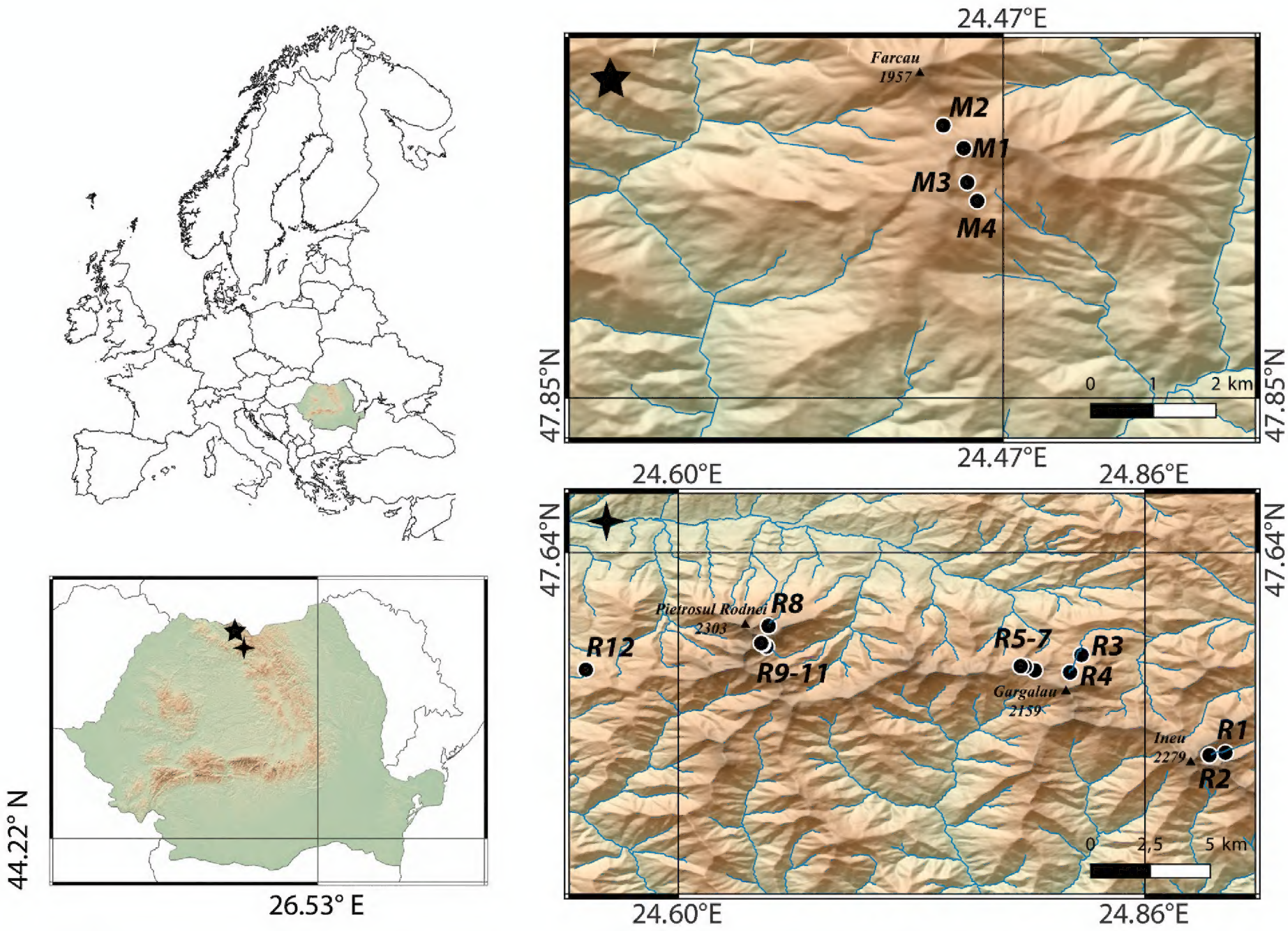

Figure 1. Geographical location of the study area and maps showing sampling sites in the East Carpathians. Star marks the Maramures Mts, spark denotes the Rodna Mts. Site codes correspond to the codes in Table 1.

The surveyed lakes in the Maramures Mts include four lakes situated in the Farcau area (Chis 2008) at altitudes ranging from 1603 m (the lower lake in the glacial cirque Vartopul Mare) to 1786 m a.s.l. (Lake Livia). The 12 studied lakes in the Rodna Mts are located at altitudes between 1378 m (Lake Taul Muced) and 1922 m a.s.l. (Lake Lala Mica) (Table 1).

Except for two forest lakes (Taul Muced, Taul Hardau), the remaining lakes are above the recent tree-line, averaging about 1600 m in the Rodna Mts (Kucsicsa 2011). The natural tree-line has been significantly impacted by deforestation and grazing, lowering the upper forest limit and fragmenting the transition between the forest and the sub-alpine zone, especially affecting dwarf pine, juniper and rhododendron growth. In the Maramures Mts, all lake catchments are treeless and heavily affected by gully erosion and shallow landslides (Balteanu et al. 2016).

The basic characteristics of the sampling sites are summarized in Table 1.

Sampling and identification

The chironomid survey was conducted during three sampling campaigns in August 2022 and July 2024 (lakes in the Maramures Mts) and in July 2023 (lakes in the Rodna Mts). Floating chironomid pupal exuviae, pupae and drowned adults were collected along the entire lake shores by skimming the water surface with a hand net (mesh size 250 µm, frame diameter 25 cm, telescopic handle).

Table 1. Basic characteristics of the sampling sites. If we were unaware of official lake names, we named the lakes for the adjacent hills. Maximum depth was either measured in the field or abstracted from available literature: *Akinyemi et al. (2013), **Mindrescu et al. (2013). Lake area was estimated using the polygon tool in Google Earth Pro. +/- indicate presence/absence of inflow/outflow. Abbreviations of catchment characteristics: **EAP** – extensive alpine pastures, **AM** – alpine meadows, **DP** – dwarf mountain pine shrubs (*Pinus mugo*), **RS** – rhododendron shrubs (*Rhododendron myrtifolium*), **NS** – Norway spruce (*Picea abies*), **BR** – bare rocks, **P** – peatbog.

Mountain range/ Lake name	Code	Geographical coordinates	Elevation (m)	Max. depth (m)	Lake area (m^2)	Inflow/ Outflow	Catchment
Maramures Mts.							
Livia	M1	47°54.26'N, 24°27.59'E	1786	3.5	622	-/-	EAP
Vinderel	M2	47°54.55'N, 24°27.33'E	1677	5.0	6183	+/+	EAP
Vartopul 1	M3	47°53.82'N, 24°27.63'E	1647	0.8	843	+/-	EAP
Vartopul 2	M4	47°53.59'N, 24°27.76'E	1603	0.8	246	+/-	EAP
Rodna Mts.							
Lala Mare	R1	47°31.68'N, 24°53.99'E	1805	1.5	6665	+/+	AM, DP
Lala Mica	R2	47°31.60'N, 24°53.46'E	1922	0.6	5332	+/+	AM, RS
Taul Hardau	R3	47°34.93'N, 24°49.20'E	1552	*3.5	568	-/-	EAP, NS
Taul Stiol	R4	47°34.35'N, 24°48.82'E	1657	5.0	10790	+/+	EAP, DP
Gargalau 3	R5	47°34.42'N, 24°47.64'E	1911	0.9	263	-/-	EAP
Gargalau 2	R6	47°34.55'N, 24°47.32'E	1887	1.2	120	-/-	EAP
Gargalau 1	R7	47°34.56'N, 24°47.18'E	1894	0.4	601	-/-	EAP
Lacul Iezer	R8	47°35.90'N, 24°38.78'E	1822	**4.5	3883	+/+	AM, BR, DP
Buhaescu 1	R9	47°35.21'N, 24°38.71'E	1825	3.0	783	+/+	AM, BR, DP
Buhaescu 2	R10	47°35.30'N, 24°38.58'E	1892	5.2	1529	+/+	AM, BR, DP
Buhaescu 3	R11	47°35.33'N, 24°38.58'E	1911	2.0	659	-/+	AM, BR, DP
Taul Muced	R12	47°34.44'N, 24°32.70'E	1378	1.0	593	-/-	P, NS, DP

Onshore, each sample was transferred to a labelled 100 ml plastic bottle and preserved in 4% formalin. In the laboratory, samples were placed in Petri dishes and all specimens were sorted under a stereomicroscope at a magnification of 7.5–50×.

Pupal exuviae were examined and classified to at least the genus level. All pupal exuviae of the least abundant morphotypes, as well as pharate adults and males associated with pupal skins, were mounted on microscopic slides, while at least 10 exuviae were prepared for the most abundant ones.

Berlese solution was used as the mounting medium. Chironomid pupal exuviae were identified using Langton and Visser (2003), while adults were identified with Langton and Pinder (2007a, 2007b). In some cases, more detailed keys were used, including Fittkau (1962); Reiss (1969); Säwedal (1976); and Langton et al. (2013). Species nomenclature and distribution follow Ashe and O'Connor (2009, 2012); and de Jong (2016).

All the slides and samples are archived in the Department of Biology and Environmental Studies, Faculty of Natural Sciences, Matej Bel University in Banská Bystrica, Slovakia.

Statistical analysis

To improve the separation of *Procladius* pupal exuviae, we focused on thoracic horn parameters of the exuviae which were associated with males of *P. sagittalis* from Lakes Vartopul 1 and Vartopul 2 and compared them with those of *P. choreus* from Western Carpathian reservoirs. Our previous research showed that only

thoracic horn characteristics were statistically significant for the identification of *Procladius* exuviae (Langton et al. 2013). We measured thoracic horn length, maximum breadth, and plastron plate diameter on a total of 30 thoracic horns from 15 *P. sagittalis* specimens and 81 thoracic horns from 41 *P. choreus* specimens.

For automatised classification, a decision tree classifier of Custode and Iacca (2023) was selected for its decision-making quality and interpretability.

Results and discussion

A total of 1118 chironomid pupal exuviae, six pupae, seven pharate adults (six males, one female), 40 males and one female were collected and identified, representing 50 chironomid species/ taxa from 26 genera across 5 subfamilies. Nine Chironomidae species were recorded for the first time in Romania.

A list of all species/ taxa recorded is provided below; sampling site codes refer to Table 1; "**Pe**" after the genus name refers to a morphotype not associated with an adult by Langton (1991); * denotes the first record of a species from Romania. For detailed data on collected specimen abundance and life stages, see Suppl. materal 1.

CHIRONOMIDAE

Tanypodinae
Procladius (*Holotanypus*) *choreus* (Meigen, 1804): M1, M2, R3
**Procladius* (*Holotanypus*) *sagittalis* (Kieffer, 1909): M3, M4
**Procladius* (*Holotanypus*) *simplicistilus* Freeman, 1948: R5
Procladius (*Holotanypus*) Pe3 Langton 1991: R7, R12
Macropelopia nebulosa (Meigen, 1804): R1, R4
Monopelopia tenuicalcar (Kieffer, 1918): R12
**Zavrelimyia punctatissima* (Goetghebuer, 1934): R4

Diamesinae
Diamesa Pe 5? Langton 1991: R4
Pseudodiamesa (*Pseudodiamesa*) *nivosa* (Goetghebuer, 1928): R8

Prodiamesinae
Prodiamesa olivacea (Meigen, 1818): R1, R8

Orthocladiinae
Brillia bifida (Kieffer, 1909): R9
Bryophaenocladius sp./ *Gymnometriocnemus* sp.: R2
Corynoneura celeripes Winnertz, 1852: R3
Corynoneura celtica Edwards, 1924: R4
Corynoneura lobata Edwards, 1924: R12
Cricotopus (*Cricotopus*) cf. *albiforceps* (Kieffer, 1916): R1
Cricotopus (*Cricotopus*) *curtus* Hirvenoja, 1973: R4
Cricotopus (*Isocladius*) *sylvestris* (Fabricius, 1794): R4
Cricotopus (*Isocladius*) *trifasciatus* (Meigen, 1810): M2
Eukiefferiella coerulescens Kieffer, 1926: R4
Eukiefferiella cf. *dittmari* Lehman, 1972: R4

Heterotrissocladius marcidus (Walker, 1856): R2, R8, R9, R10, R11
Krenosmittia camptophleps (Edwards, 1929): R4
Limnophyes cf. *asquamatus* Andersen, 1937: M1, M2, R5, R6, R7, R8
Limnophyes cf. *gelasinus* Saether 1990: R2
Orthocladius (*Mesorthocladius*) *frigidus* (Zetterstedt, 1838): R8
Psectrocladius (*Allopsectrocladius*) *obvius* (Walker, 1856): M4, R4
**Psectrocladius* (*Allopsectrocladius*) *platypus* (Edwards, 1929): M4, R12
**Psectrocladius* (*Psectrocladius*) *oligosetus* Wuelker, 1956: R3, R7, R12
Rheocricotopus (*Rheocricotopus*) *effusus* (Walker, 1856): R4
Thienemanniella Pe1 Langton 1991: R4

Chironominae
Chironomus (*Chironomus*) cf. *aberratus* Keyl, 1961: M2, M4, R3, R4, R5
Chironomus (*Chironomus*) cf. *holomelas* Keyl, 1961: R6
Chironomus (*Chironomus*) cf. *longistylus* Goetghebuer, 1921: M2, M3, M4, R3, R7
Chironomus (*Lobochironomus*) *dorsalis* Meigen, 1818: R5, R6
Chironomus (*Lobochironomus*) Pe2 Langton 1991: R3, R5, R6, R7
Chironomus (*Chironomus*) sp.: R3
Cladopelma goetghebueri Spies et Saether, 2004: R12
Polypedilum (*Pentapedilum*) cf. *uncinatum* (Goetghebuer, 1921): R3
**Synendotendipes lepidus* (Meigen, 1830): R5
Synendotendipes sp.: M3, M4, R3, R5, R6, R7, R12
**Micropsectra bodanica* Reiss, 1969: M2
Micropsectra junci (Meigen, 1818): R9
Micropsectra lindrothi Goetghebuer, 1931: M2
**Micropsectra notescens* (Walker, 1856): R10, R11
Paratanytarsus austriacus (Kieffer, 1924): M2, R4
Tanytarsus bathophilus Kieffer 1911: R4, R8
Tanytarsus gregarius Kieffer, 1909: R1, R2, R4
**Tanytarsus miriforceps* (Kieffer, 1921): R2, R4
Tanytarsus Pe 4c Langton 1991/ *debilis* (Meigen, 1830): M2, M3

Comments on new records of Chironomidae from Romania

Zavrelimyia punctatissima (Goetghebuer, 1934)

Material examined. • 6 pupal exuviae, Taul Stiol (R4), 3 July 2023.

Distribution. West Palaearctic. The species is known from a few European countries: Austria, France, Germany, Italy, Norway, and Slovakia (Ashe and O'Connor 2009).

Habitat. It is a cold-stenothermal species adapted to live in oligotrophic waters with high oxygen concentrations (Boggero and Lencioni 2006). Boggero (2018) considers it strictly rheophilous. The species is a typical inhabitant of the littoral, inlets and outlets of alpine lakes (Rossaro et al. 2006; Hamerlík and Bitušík 2008; Steingruber et al 2013).

Remarks. Pupal exuviae closely resemble those of *Zavrelimyia hirtimana* (Kieffer, 1918), but all collected specimens exhibit very small plastron plates. The plastron plate diameter to thoracic horn length (0.054–0.055) aligns with the diagnosis of Langton and Visser (2003) for *Z. punctatissima*.

Procladius (*Holotanypus*) *sagittalis* (Kieffer, 1909)

Material examined. • 11 pupal exuviae, 1 male, Lake Vartopul 1 (M3), 1 July 2024 • 25 pupal exuviae, 2 pupae, 1 pharate adult – male, Lake Vartopul 2 (M4), 1 July 2024.

Distribution. Palaearctic and Oriental. Distributed from Europe and North Africa through Iran to Japan and the Russian Far East. One record is known from China (Ashe and O'Connor 2009; de Jong 2016).

Habitat. Generally, larvae of the subgenus *Holotanypus* are dwellers of stagnant and slow flowing waters regardless of size or volume. Langton (1991) noted that *P. sagittalis* typically occurs in shallow water under 2 m deep, which aligns with the findings from small-volume habitats (e.g., Velasco et al. 1993; Hirabayashi et al. 2004). However, the species has also been recorded from artificial ponds and reservoirs, as well as from backwaters, and large rivers (Bitušík 1993; Evrard 1994; Móra et al. 2010; Quintana et al. 2018). It should be noted that ecological information on the species could be more accurate if the identification of the preimaginal stages were more reliably resolved.

Remarks. Identification of the pupal exuviae, and even adult males of *Procladius* (*Holotanypus*) is extremely challenging (Vallenduuk and Moller Pillot 2007). The extended key for exuvia (Langton et al. 2013) is not reliably applicable to *Procladius* material collected from the Maramures lakes due to the variability of the tergite armament. Notably, the distinctive "fish scale" armament typical of *P. choreus* can also appear in some specimens of *Procladius* Pe3. The parameters of the thoracic horns appear to be more reliable characteristics for identification.

Thus, we propose a model that classifies input data with 97% accuracy, achieving 100% for *P. sagittalis* and 96% for *P. choreus*. Based on the decision tree trained on our dataset, we constructed an identification key for distinguishing the aforementioned *Procladius* species (Table 2). We are aware of the tentative nature of the key and acknowledge that a larger dataset would improve the tuning and evaluation of the proposed system. Therefore, the proposed key should be used with great caution.

Table 2. A tentative identification key for *Procladius choreus* and *P. sagittalis* based on thoracic horn characteristics, using the decision tree classifier of Custode and Iacca (2023).

Question number	Question text	Result	
		Yes	No
1	Is the length of the thoracic horn ≤ 469 µm?	*P. sagittalis*	2
2	Is the diameter of the plastron plate ≤ 93 µm?	3	4
3	Is the length of the thoracic horn ≤ 478 µm?	5	*P. choreus*
4	Is the breadth of the thoracic horn ≤ 144 µm?	*P. choreus*	*P. sagittalis*
5	Is the length of the thoracic horn ≤ 476 µm?	*P. choreus*	*P. sagittalis*

Procladius (*Holotanypus*) *simplicistilus* Freeman, 1948

Material examined. • 1 pharate adult – male, Lake Gargalau 3 (R5), 6 July 2023.

Distribution. Palaearctic. The species was recorded only from a few countries in West and North Europe, but also from the Far East of Russia (Ashe and O'Connor 2009).

Habitat. The ecological requirements of this species are not sufficiently known because of the problematic identification of the pre-imaginal stages. Generally, larvae inhabit stagnant waters, they are resistant to low pH values (Murray and Baars 2006; Perova 2008; Baars et al. 2014) and salinity (Kawai et al. 2000).

Remarks. An adult male with associated exuviae confirms the presence of the species in Romania.

Psectrocladius (*Allopsectrocladius*) *platypus* (Edwards, 1929)

Material examined. • 64 pupal exuviae, 1 pharate adult – male, Lake Vartopul 2 (M4), 1 July 2024 • 1 pupal exuviae, Taul Hardau (R3), 6 July 2023.

Distribution. Palaearctic. Known from several European countries, as well as Turkey and Algeria (Ashe and O'Connor 2009).

Habitat. The species is typical of small, acidic, stagnant waters in moorlands and peat bogs. In addition to tolerating low pH, it can withstand low oxygen levels in polyhumic waters; however, larvae are also found in lake littorals and small streams with slow currents (Moller Pillot 2013 and references therein). In the Western Carpathians, pupal exuviae were collected from a small, non-acid sub-alpine lake (Bitušík et al. 2006). The species is frequently recorded in temporary pools and ponds (e.g., Bazzanti et al. 1997; Puntí et al. 2007), as well as ephemeral waters (Moller Pillot 2003), indicating relatively high dispersal potential of females.

Remarks. The findings indicate the humic conditions of Taul Hardau and suggest at least partial drying of Lake Vartopul 2.

Psectrocladius (*Psectrocladius*) *oligosetus* Wuelker, 1956

Material examined. • 26 pupal exuviae, Taul Hardau (R3), 6 July 2023; 59 pupal exuviae, Taul Muced (R12), 7 July 2023 • 1 pupal exuviae, Lake Gargalau 1 (R7), 6 July 2023.

Distribution. Palaearctic. Recorded from several European countries ranging from the south (Sicily) to the north (Scandinavia) and from the west (Ireland) to the eastern part of Russia (Ashe and O'Connor 2009).

Habitat. Cold-stenothermic species occurring in lakes in mountain regions (e.g., Laville and Vinçon 1986, Bitušík et al. 2007, Boggero 2018), although Rieradevall et al. (2007) found it in intermittent mountain headstreams. The species shows an apparent affinity for low pH humic waters (e.g., Ruse 2002; Bitušík and Svitok 2006; Moller Pillot 2013; Bitušík et al. 2020).

Remarks. This finding, along with an earlier record from Ukraine (Bitušík et al. 2020), partially fills the distribution gap of the species extending from the Baltic republics across Poland to the Balkans.

Synendotendipes lepidus (Meigen, 1830)

Material examined. • 4 males, 1 female, Lake Gargalau 3 (R5), 6 July 2023.

Distribution. Palaearctic. Widespread in Europe (Ashe and Cranston 1984, Moller Pillot 2009), and it has been reported from Turkey (Ozbek et al. 2018) and the Russian Far East (Orel 2016).

Habitat. The species has been recorded mainly from stagnant waters regardless of size and trophic status. Lundström et al. (2010) collected adults from temporary wetlands, and there are data from lowland brooks (Ozbek et al. 2018). Like other species of the genus, it tolerates acid conditions of peatland pools (Plóciennik et al. 2018). According to Moller Pillot (2009), the larvae are miners in the tissues of *Nuphar lutea*. However, they evidently utilize other types of littoral vegetation, such as sedges, since *N. lutea* does not occur in the studied lakes.

Remarks. Species of the genus *Synendotendipes* are indistinguishable as pupal exuviae, so it is not possible to confirm if *Synendotendipes* pupal exuviae recorded in other lakes also belong to *S. lepidus*.

Micropsectra bodanica Reiss, 1969

Material examined. • 1 male, Lake Vinderel (M2), 1 July 2023.

Distribution. Palaearctic. The species has so far been recorded from only a few countries, such as Germany, Austria, and Portugal, with its occurrence in Corsica and Slovakia not yet confirmed (Moubayed-Breil and Ashe 2012; Novikmec et al. 2015).

Habitat. Ecological requirements of the species are still inadequately understood. Reiss (1969) considered the species (together with *M. attenuata*) as cold stenothermic and polyoxybiontic, typically inhabiting mosses on stones in springs and the upper stretches of streams (see also Langton and Visser 2003). Records of the pupal exuviae of *M. attenuata*/*bodanica* in the Western Carpathians come from headwater streams (one even artificially modified) with stony bottoms but without moss growths (Novikmec et al. 2015). It can be assumed that the collected adult male comes from a spring or small stream flowing in Lake Vinderel.

Remarks. Since the pupal exuviae of *M. bodanica* are indistinguishable from those of *M. attenuata* (Langton and Visser 2003), the first record of *M. bodanica* based on an adult male in Romania is particularly valuable.

Micropsectra notescens (Walker, 1856)

Material examined. • 26 pupal exuviae, Lake Buhaescu 2 (R10), 5 July 2023 • 22 pupal exuviae, Lake Buhaescu 3 (R11), 5 July 2023.

Distribution. Palaearctic. Widespread in Europe including the Canary Islands (Langton and Visser 2003); also recorded in Morocco (Kettani and Langton 2011).

Habitat. Traditionally, the species is considered cold stenothermic and polyoxybiontic (Säwedal 1976). It has been documented in mountain, boreal and woodland springs and spring brooks (Orendt 2000; Ilmonen et al. 2009; Lencioni et al. 2012), as well as alpine lakes and ponds (Bitušík et al. 2006; Oertli et al. 2010; Lods-Crozet et al. 2012). However, data from low-altitude streams suggest a wider temperature tolerance (Móra and Szivák 2012). Its presence in temporary habitats, such as fountains (Oboňa et al. 2017) and temporarily flooded wetlands (Lundström et al. 2010), indicates a high distribution potential of females.

Remarks. The presence of *M. notescens* in Romania has already been reported by Säwedal (1976) based on two males collected by Andrzej Kownacki from the Fagaras Mts. However, the species is not listed in the latest checklist of Romanian Chironomidae (Tatole 2023).

Tanytarsus miriforceps (Kieffer, 1921)

Material examined. • 13 pupal exuviae, 1 adult – male, Taul Stiol (R4), 3 July 2023 • 110 pupal exuviae, 1 pharate adult – male, 1 adult – male, Lake Lala Mica (R2), 4 July 2023.

Distribution. Holarctic. The species is widespread across Europe, primarily in northern and western countries (Ashe and Cranston 1984; de Jong 2016), with recent records in Poland, Montenegro and European Russia (Gilka and Dominiak 2007; Krasheninnikov 2014; Gadawski et al. 2022). It is also known from Canada (de Jong 2016); and the Far East (Orel 2018).

Habitat. Current data indicate that this species is a limnobiont inhabiting lakes mainly at high altitudes and high latitudes (except for Lake Skadar), suggesting a preference for low temperatures (e.g., Verneaux and Aleya 1999).

Remarks. The species exhibits symptoms of glacial relictualism as already suggested by Reiss and Fittkau (1971) and Reiss (1984).

The collection of floating chironomid pupal exuviae from the lakes in this study provides an excellent basis for the chironomid inventory of the area. For species identification, exuviae are sometimes even more useful than adults (Prat et al. 2016). However, it should be noted that our species inventory from a "snapshot" survey cannot be comprehensive, as not all species present in a site emerge simultaneously. Even though the collection was conducted during a period suitable for recording most species (Wilson and Ruse 2005; own data), we believe that the absence of cold-stenothermic species/ genera in our collection is due to their early spring emergence.

Compared to some Central and East European countries, such as Hungary, Ukraine, Czechia, Slovakia, and Poland, the Romanian chironomid fauna is relatively well-studied. The latest checklist of the family from Romania (Tatole 2023) includes 517 species, with recent records of nine additional species raising this total to 526. This number could be even higher if species within the genus *Limnophyes* and some *Chironomus* species could be reliably identified.

A detailed examination of the chorological data in the aforementioned checklist reveals a lack of records from the Rodna and Maramures Mountains. Chironomids are also absent from the list of Diptera collected in Maramures Mountains Nature Park (Parvu 2008). The only available information on chironomids associated with the studied lakes comes from the sediment core of Lake Taul Muced, where subfossil larval remains were identified to morphotype level (Diaconu et al. 2017).

Here, we provide the first information about chironomid occurrence within the protected areas of Maramures Mountains Nature Park and Rodna Mountains National Park, offering potential value to use by the administrations of both parks.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: PB. Data curation: PB. Formal analysis: MN, AD. Funding acquisition: PB. Investigation: AD. Software: AD. Validation: LH. Visualization: MN. Writing – original draft: MN, PB, LH, AD, VS. Writing – review and editing: PB, MN, VS, LH.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

References

Akinyemi FO, Hutchinson SM, Mîndrescu M, Rothwell JJ (2013) Lake sediment records of atmospheric pollution in the Romanian Carpathians. Quaternary International 293: 105–113. https://doi.org/10.1016/j.quaint.2012.01.022

Ashe P, Cranston PS (1984) Family Chironomidae. In: Soós Á, Papp L (Eds) Catalogue of Palaearctic Diptera: Psychodidae-Chironomidae, Vol. 2. Akademiai Kiadó, Budapest, 113–441.

Ashe P, O'Connor JP (2009) A World Catalogue of Chironomidae (Diptera). Part 1. Buchonomyiinae, Chilenomyiinae, Podonominae, Aphroteniinae, Tanypodinae, Usambaromyiinae, Diamesinae, Prodiamesinae and Telmatogetoninae. Irish Biogeographical Society and National Museum of Ireland, Dublin, 445 pp.

Ashe P, O'Connor JP (2012) A World Catalogue of Chironomidae (Diptera). Part 2. Orthocladiinae. Irish Biogeographical Society and National Museum of Ireland, Dublin, 968 pp.

Baars JR, Murray DA, Hannigan E, Kelly-Quinn M (2014) Macroinvertebrate assemblages of small upland peatland lakes in Ireland. Biology and Environment: Proceedings of the Royal Irish Academy 114(3): 233–248. https://doi.org/10.1353/bae.2014.0016

Balteanu D, Nastase M, Dumitrascu M, Grigorescu I (2016) Environmental changes in the Maramureş Mountains Natural Park. In: Zhelezov G (Ed.) Sustainable Development in Mountain Regions: Southeastern Europe, Second Edition. Springer International Publishing, Switzerland, 335–348. https://doi.org/10.1007/978-3-319-20110-8_23

Battarbee RW, Bennion H (2012) Using palaeolimnological and limnological data to reconstruct the recent history of European lake ecosystems: Introduction. Freshwater Biology 57(10): 1979–1985. https://doi.org/10.1111/j.1365-2427.2012.02857.x

Bazzanti M, Seminara M, Baldoni S (1997) Chironomids (Diptera: Chironomidae) from three temporary ponds of different wet phase duration in central Italy. Journal of Freshwater Ecology 12(1): 89–99. https://doi.org/10.1080/02705060.1997.9663512

Bitušík P (1993) New records of chironomids (Diptera. Chironomidae) from Czech Republic and Slovak Republic. Biologia, Bratislava 48: 189–194.

Bitušík P, Svitok M (2006) Structure of chironomid assemblages along environmental and geographical gradients in the Bohemian Forest lakes (Central Europe): An exploratory analysis. Biologia 61(20): S467–S476. https://doi.org/10.2478/s11756-007-0063-y

Bitušík P, Svitok M, Kološta P, Hubková M (2006) Classification of the Tatra Mountains lakes (Slovakia) using chironomids (Diptera, Chironomidae). Biologia 61(Suppl. 18): S191–S201. https://doi.org/10.2478/s11756-006-0131-8

Bitušík P, Svitok M, Bačík J (2007) Chironomids (Diptera: Chironomidae) of man-made reservoirs in the Banská Štiavnica mining region (Slovakia). Acta Zoologica Universitatis Comenianae 47(2): 115–126.

Bitušík P, Novikmec M, Hamerlík L (2020) Chironomids (Insecta, Diptera, Chironomidae) from alpine lakes in the Eastern Carpathians with comments on newly-recorded species from Ukraine. Biodiversity Data Journal 8: e49378. https://doi.org/10.3897/BDJ.8.e49378

Bitušík P, Novikmec M, Svitok M, Hamerlík L (2024) New faunistic records of chironomids and phantom midges (Diptera, Chironomidae and Chaoboridae) from Ukraine indicate recent climatic refugia in the Eastern Carpathians. ZooKeys 1211: 349–367. https://doi.org/10.3897/zookeys.1211.125436

Boggero A (2018) Macroinvertebrates of Italian mountain lakes: A review. Redia – Giornale di Zoologia 101: 34–45. https://doi.org/10.19263/REDIA-101.18.06

Boggero A, Lencioni V (2006) Macroinvertebrates assemblages of high altitude lakes, inlets and outlets in the southern Alps. Archiv für Hydrobiologie 165: 37–61. https://doi.org/10.1127/0003-9136/2006/0165-0037

Chis VT (2008) Geographical background elements of the Viseu River Basin (Maramureş, Romania). In: Curtean-Banaduc A, Banaduc D, Sirbu I (Eds) The Maramures Mountains Nature Park. Transylvanian Review of Systematical and Ecological Research 5: 1–4.

Chis VT (2010) Geographical introductory characterization of the Rodna Mountains – Rodna Mountains National Park (Eastern Carpathians, Romania). Transylvanian Review of Systematical and Ecological Research 9: 1–14.

Costea M (2008) The characteristics of the hydrographical basins of the Maramures Mountains (Maramures, Romania). In: Curtean-Banaduc A, Banaduc D, Sirbu I (Eds)

The Maramures Mountains Nature Park. Transylvanian Review of Systematical and Ecological Research 5: 13–20.

Curtean-Banaduc A, Banaduc D, Sirbu I (Eds) (2008) The Maramures Mountains Nature Park. Transylvanian Review of Systematical and Ecological Research 5: 1–222.

Custode LL, Iacca G (2023) Evolutionary Learning of Interpretable Decision Trees. IEEE Access 11: 6169–6184. https://doi.org/10.1109/ACCESS.2023.3236260

de Jong Y (2016) Fauna Europaea. Fauna Europaea Consortium. Checklist dataset. https://doi.org/10.15468/ymk1bx [GBIF.org on 2024-03-21]

Diaconu AC, Toth M, Lamentowicz M, Heiri O, Kuske E, Tanţau I, Panait A-M, Braun M, Feurdean A (2017) How warm? How wet? Hydroclimate reconstruction of the past 7500 years in northern Carpathians, Romania. Palaeogeography, Palaeoclimatology, Palaeoecology 482: 1–12. https://doi.org/10.1016/j.palaeo.2017.05.007

Evrard M (1994) Check-list of the Chironomidae (Diptera) of the river Meuse and two of its tributaries. Annales de Limnologie – International Journal of Limnology 30(2): 123–129. https://doi.org/10.1051/limn/1994008

Farcas S, Tantau I, Mindrescu M, Hurdu B (2013) Holocene vegetation history in the Maramures mountains (Northern Romanian Carpathians). Quaternary International 293: 92–104. https://doi.org/10.1016/j.quaint.2012.03.057

Fittkau EJ (1962) Die Tanypodinae (Diptera: Chironomidae) (Die tribus Anatopyniini, Macropelopiini und Pentaneurini). Abh. Larvalsyst. Insekten 6: 1–453.

Gadawski P, Rossaro B, Gilka W, Montagna M, Zawal A, Grabowski M (2022) First insights into the diversity and ecology of non-biting midges (Diptera: Chironomidae) of the unique ancient Skadar Lake basin (Montenegro/Albania). Journal of Great Lakes Research 48(2): 538–550. https://doi.org/10.1016/j.jglr.2021.02.003

Gilka W, Dominiak P (2007) Tanytarsini (Diptera: Chironomidae) of the Kashubian Lakeland. Fragmenta Faunistica 50(1): 47–55. https://doi.org/10.3161/00159301FF2007.50.1.047

Hamerlík L, Bitušík P (2008) Records of Chironomidae (Diptera) from a subalpine Tatra lake, new in Slovakia. Lauterbornia 62: 131–133.

Hirabayashi K, Matsuzawa M, Yamamoto M, Nakamoto N (2004) Chironomid fauna (Diptera, Chironomidae) in a filtration plant in Japan. Journal of the American Mosquito Control Association 20(1): 74–82.

Ilmonen J, Paasivirta L, Virtanen R, Muotka T (2009) Regional and local drivers of macroinvertebrate assemblages in boreal springs. Journal of Biogeography 36(5): 822–834. https://doi.org/10.1111/j.1365-2699.2008.02045.x

Kawai K, Morihiro S, Imabayashi H (2000) Transectional distribution patterns of chironomid larvae in estuaries. Medical Entomology and Zoology 51(3): 215–220. https://doi.org/10.7601/mez.51.215

Kettani K, Langton PH (2011) New data on the Chironomidae (Diptera) of the Rif (northern Morocco). Polish Journal of Entomology 80(3): 587–595. https://doi.org/10.2478/v10200-011-0046-8

Krasheninnikov AB (2014) Preliminary data on the chironomid fauna (Diptera, Chironomidae) of the Pay-Khoy ridge. V.Ya. Levanidov's Biennial Memorial Meetings. Dalnauka, Vladivostok 6: 340–347.

Kucsicsa G (2011) Considerations on the timberline in the Rodna Mountains National Park. Revue Roumaine de Géographie/Romanian Journal of Geography 55(1): 57–61.

Langton PH (1991) A key to pupal exuviae of West Palaearctic Chironomidae. Privately published by PH Langton, 3 St. Felix Road, Ramsay Forty Foot, Cambridgeshire, England, PE 17 1YH, 386 pp.

Langton PH, Pinder LCV (2007a) Keys to the adult male Chironomidae of Britain and Ireland 1. Scientific Publication – Freshwater Biological Association 64: 1–239.

Langton PH, Pinder LCV (2007b) Keys to the adult male Chironomidae of Britain and Ireland 2. Scientific Publication – Freshwater Biological Association 64: 1–168.

Langton PH, Visser H (2003) Chironomidae exuviae. A key to pupal exuviae of the West Palaearctic Region. Interactive Identification System for the Europaean Limnofauna (IISEL), World Biodiversity Database, CD–ROM Series.

Langton PH, Bitusik P, Mitterova J (2013) A contribution towards a revision of West Palaearctic *Procladius* Skuse (Diptera: Chironomidae). Chironomus 26(26): 41–44. https://doi.org/10.5324/cjcr.v0i26.1620

Laville H, Vinçon G (1986) Inventaire 1986 des Chironomidés (Diptera) connus des Pyrénées. Annales de Limnologie 22(3): 239–251. https://doi.org/10.1051/limn/1986022

Lencioni V, Marziali L, Rossaro B (2012) Chironomids as bioindicators of environmental quality in mountain springs. Freshwater Science 31(2): 525–541. https://doi.org/10.1899/11-038.1

Lods-Crozet B, Oertli B, Robinson CT (2012) Long-term patterns of chironomid assemblages in a high elevation stream/lake network (Switzerland) – Implications to global change. Fauna norvegica 31: 71–71. https://doi.org/10.5324/fn.v31i0.1361

Lundström JO, Brodin Y, Schäfer ML, Vinnersten TP, Östman Ö (2010) High species richness of Chironomidae (Diptera) in temporary flooded wetlands associated with high species turn-over rates. Bulletin of Entomological Research 100(4): 433–444. https://doi.org/10.1017/S0007485309990472

Mindrescu M, Evans IS (2014) Cirque form and development in Romania: Allometry and the buzz-saw hypothesis. Geomorphology 208: 117–136. https://doi.org/10.1016/j.geomorph.2013.11.019

Mindrescu M, Cristea AI, Hutchinson SM, Florescu G, Feurdean A (2013) Interdisciplinary investigations of the first reported laminated lacustrine sediments in Romania. Quaternary International 293: 219–230. https://doi.org/10.1016/j.quaint.2012.08.2105

Moller Pillot HKM (2003) Hoe waterdieren zich handhaven in een dynamische wereld. 10 jaar onderzoek in de Roodloop, een bovenloopje van de Reusel in Noord-Brabant. Stichting het Noordbrabants Landschap, Haaren, 182 pp.

Moller Pillot HKM (2009) Chironomidae larvae of the Netherlands and adjacent lowlands: biology and ecology of the Chironomini. KNNV Publishing, Zeist, 270 pp.

Moller Pillot HKM (2013) Chironomidae Larvae of the Netherlands and Adjacent Lowlands. Biology and Ecology of the aquatic Orthocladiinae. KNNV Publishing, Zeist, 312 pp.

Móra A, Szivák I (2012) Spatial distribution and diversity of chironomid assemblages in a small hilly stream (Diptera: Chironomidae). Aquatic Insects 34: 127–138. https://doi.org/10.1080/01650424.2012.643042

Móra A, Kálmán Z, Soós N, Tóth A, Deák C, Ambrus A, Csabai Z (2010) Data to the aquatic invertebrate fauna of Kis-Duna (Kismaros) with first Hungarian records of three chironomid species. Acta Biologica Debrecina – Oecologica Hungarica 21: 127–138.

Moubayed-Breil J, Ashe P (2012) An updated checklist of the Chironomidae of Corsica with an outline of their altitudinal and geographical distribution (Diptera). Ephemera 13(1): 13–39.

Murray DA, Baars J-R (2006) *Parapsectra uliginosa* Reiss, 1969 (Diptera, Chironomidae) new to Ireland and association of exuviae of *Procladius* Pe1 (sensu Langton) with *P. simplicistilus* Freeman, 1948. Dipterists Digest 13: 166–168.

Nicacio G, Juen L (2015) Chironomids as indicators in freshwater ecosystems: An assessment of the literature. Insect Conservation and Diversity 8(5): 393–403. https://doi.org/10.1111/icad.12123

Novikmec M, Hamerlík L, Svitok M, Matúšová Z, Bitušík P (2015). Remarkable faunistic records of aquatic insects from streams of the Kremnické vrchy Mountains, Slovakia. Lauterbornia 79: 51–57.

Oboňa J, Demková L, Smoľák R, Dominiak P, Ščerbáková S (2017) Invertebrates in overlooked aquatic ecosystem in the middle of the town. Periodicum biologorum 119(1): 47–54. https://doi.org/10.18054/pb.v119i1.4169

Oertli B, Indermuehle N, Angélibert S, Hinden H, Stoll A (2010) Macroinvertebrate assemblages in 25 high alpine ponds of the Swiss National Park (Cirque of Macun) and relation to environmental variables. In: Oertli B, Céréghino R, Biggs J, Declerck S, Hull A, Miracle MR (Eds) Pond Conservation in Europe. Springer Dordrecht Heidelberg London New York, 29–41. https://doi.org/10.1007/978-90-481-9088-1_4

Orel OV (2016) Fauna of non-biting midges of subfamily Chironominae (Diptera, Chironomidae) from the Russian Far East. Freshwater Life 2: 185–196.

Orel OV (2018) Fauna of non-biting midges of the subfamily Chironominae (Diptera, Chironomidae) of the extreme North-East part of Asia. Euroasian Entomological Journal 17(3): 191–200. https://doi.org/10.15298/euroasentj.17.3.09

Orendt C (2000) The chironomid communities of woodland springs and spring brooks, severely endangered and impacted ecosystems in a lowland region of eastern Germany (Diptera: Chironomidae). Journal of Insect Conservation 4: 79–91. https://doi.org/10.1023/A:1009684015564

Ozbek M, Tasdemir A, Cil EA, Somek H, Yildiz S (2018) Assessing the trophic level of a Mediterranean Stream (Nif Stream, İzmir) using benthic macro-invertebrates and environmental variables. Turkish Journal of Fisheries and Aquatic Sciences 19(3): 179–190. https://doi.org/10.4194/1303-2712-v19_3_01

Parvu C (2008) Diptera (Insecta) of the Maramures Mountains Nature Park (Maramures, Romania). Transylvanian Review of Systematical and Ecological Research 5: 155–164.

Perova SN (2008) The taxonomic composition of macrozoobenthos in central Russian small karst lakes. Inland Water Biology 1(4): 371–379. https://doi.org/10.1134/S1995082908040093

Plóciennik M, Skonieczka M, Antczak O, Siciński J (2018) Phenology of non-biting midges (Diptera Chironomidae) in peatland ponds, Central Poland. Entomologica Fennica 29(2): 61–74. https://doi.org/10.33338/ef.71014

Prat N, Puntí T, Rieradevall M (2016) The use of larvae and pupal exuviae to study the biodiversity of Chironomidae in Mediterranean streams. Journal of Entomological and Acarological Research 48(1): 29–36. https://doi.org/10.4081/jear.2016.5529

Puntí T, Rieradevall M, Prat N (2007) Chironomidae assemblages in reference condition Mediterranean streams: environmental factors, seasonal variability and ecotypes. Fundamental and Applied Limnology – Archiv für Hydrobiologie 170(2): 149–166. https://doi.org/10.1127/1863-9135/2007/0170-0149

Quintana R, Corral-Hernandéz E, López S, Iturrondobeitia JC (2018) Faunistic study of Chironomidae (Diptera, Nematocera) collected in the Wastewater Treatment Plant of Sestao (Biscay, Basque Autonomous Community) and surrounding areas. Boletín de la Asociación Española de Entomología 42(1): 49–69.

Reiss F (1969) Revision der Gattung *Micropsectra* Kieff., 1909 (Diptera, Chironomidae). 1. Die *attenuata*-Gruppe der Gattung *Micropsectra*. Beschreibung 5 neuer Arten aus

Mitteleuropa und Nordafrika. Deutsche Entomologische Zeitschrift 16(4–5): 431–449. https://doi.org/10.1002/mmnd.4810160414

Reiss F (1984) Die Chironomidenfauna (Diptera, Insecta) des Osterseegebietes in Oberbayern. Berichte der ANL 8: 186–194.

Reiss F, Fittkau EJ (1971) Taxonomie und Ökologie europâisch Verbreiteter *Tanytarsus* Arten (Chironomidae, Diptera). Archiv für. Hydrobiology Suppl. 40(1–2): 75–200.

Rieradevall M, Chaves ML, Prat N (2007) High altitude Chironomidae (Diptera) of Serra da Estrela (Portugal): Additions to the Portuguese and Iberian peninsula fauna. Graellsia 63 (2): 273–278. https://doi.org/10.3989/graellsia.2007.v63.i2.94

Rossaro B, Lencioni V, Boggero A, Marziali L (2006) Chironomids from Southern Alpine running waters: ecology, biogeography. Hydrobiologia 562: 231–246. https://doi.org/10.1007/s10750-005-1813-x

Ruse L (2002) Chironomid pupal exuviae as indicators of lake status. Archiv für Hydrobiologie 153: 367–390. https://doi.org/10.1127/archiv-hydrobiol/153/2002/367

Ruse L (2010) Classification of nutrient impact on lakes using the chironomid pupal exuvial technique. Ecological Indicators 10(3): 594–601. https://doi.org/10.1016/j.ecolind.2009.10.002

Säwedal L (1976) Revision of the *notescens*-group of the genus Micropsectra Kieffer, 1909 (Diptera: Chironomidae). Insect Systematics & Evolution 7(2): 109–144. https://doi.org/10.1163/187631276X00207

Steingruber S, Boggero A, Pradella C, Dumnicka E, Colombo L (2013) Can we use macroinvertebrates as indicators of acidification of high-altitude Alpine lakes? Bollettino della Società ticinese di scienze naturali 101: 23–34.

Tatole V (2023) An updated checklist of chironomid species (Diptera, Chironomidae) from Romania. Travaux du Museum National d'Histoire Naturelle "Grigore Antipa"/ Muzeul National de Istoire Naturala "Grigore Antipa" 66(1): 17–105. https://doi.org/10.3897/travaux.66.e102065

Vallenduuk HJ, Moller Pillot HKM (2007) Chironomidae larvae of the Netherlands and adjacent lowlands. General ecology and Tanypodinae. KNNV Publishing, Zeist, 144 pp.

Velasco J, Millán A, Ramírez-Díaz L (1993) Colonización y sucesión de nuevos medios acuáticos I. Composición y estructura de las comunidades de insectos. Limnetica 9: 73–85. https://doi.org/10.23818/limn.09.10

Verneaux V, Aleya L (1999) Comparaison des peuplements chironomidiens du lac de l'Abbaye obtenus par différentes méthodes d'échantillonnage. Intérêts de la récolte des exuvies nymphales. Revue des Sciences de l'Eau 12: 45–63. https://doi.org/10.7202/705343ar

Wilson RS, Ruse LP (2005) A guide to the identification of genera of chironomid pupal exuviae occurring in Britain and Ireland and their use in monitoring lotic and lentic freshwaters. Freshwater Biological Association Special Publication No. 13, Windermere, 176 pp.

Supplementary material 1

List of chironomid taxa collected from studied lakes in the Maramures Mts. and the Rodna Mts.

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Data type: docx

Explanation note: Sampling site codes refer to codes in Table 1; numbers refer to number of chironomid pupal exuviae collected; P – pupa, M – male, F – female (in case of adult specimens), PhM – pharate adult male, PhF – pharate adult female, * – first record of species for Romania.

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